

[19] PEOPLE'S REPUBLIC OF CHINA  
PATENT OFFICE

## [12] LETTER PATENT DESCRIPTION

[54] SODIUM CHLORATE OXYGEN CANDLE

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C01B 13/02

[21] Appl. No.: 89100611.7

[22] Appl. Date: January 28, 1989

[11] Publication No.: CN 1035248A

[43] Publication Date: September 6, 1989

[51] Int.Cl: A62B 7/08

## [57] ABSTRACT

A catalytic decomposition sodium chlorate Chemical oxygen candle can be used for self rescue in oxygen deficiency environment, especially suitable as a initiation device in chemical oxygen self rescue devices. The Oxygen candle has a major component sodium chlorate and appropriate catalysts, additives and excipients. The oxygen candle can be ignited using a percussion primer and sustain the burning and evolve high purity oxygen. It has high oxygen generation rate and very low total heat release.

6 pages, 1 drawing

(BJ) No.1456

### Claims

1. A chemical oxygen candle with sodium chlorate as main oxygen source. It can be used to supply oxygen for self rescue. The chemical oxygen candle is comprised of ignition pellet, flash layer and candle body.
2. The said chemical oxygen candle in claim 1 is comprised (weight percentage)  $\text{NaClO}_3$  81-96, Mg 0-5.0,  $\text{Co}_2\text{O}_3$  2.0-7.0,  $\text{MnO}_2$  0-5.0,  $\text{Li}_2\text{O}_2$  1.0-6.5, and Gaoling 1.0-8.0.
3. The flash layer of the said chemical oxygen candle in claim 1 is comprised of  $\text{NaClO}_3$  70-90, Mg 1-10,  $\text{Co}_2\text{O}_3$  0-7,  $\text{B}_2\text{O}_3$  0-6,  $\text{Li}_2\text{O}_2$  1-7, and Gaoling 1-10.
4. The said chemical oxygen candle in claim 1 is consisted of a percussion primer, ignition pellet, flash layer and candle body. The primer ignites the ignition pellet, the ignition pellet ignites the flash layer and then the candle body. The candle body then self-sustains the decomposition and evolves high purity oxygen for breathing.
5. The said chemical oxygen candle in claim 1 is catalytic decomposition type, which requires little or no fuel. Once ignited, the candle can self-sustain the decomposition and evolve breathable oxygen.
6. The said candle in claim 1 is characterized by the fact that the oxygen evolution rate can be regulated by catalysts, additives, and/or excipients.

## DESCRIPTION

This invention is related to a chemical oxygen generaor, which can be used as an initiator for chemical oxygen self rescue devices.

Chemical oxygen generator, sodium chlorate candle, has been known for a long time. A number of patents were granted abroad during the 60's and 70's. In addition to the major component  $\text{NaClO}_3$ , the oxygen candles contained fuel and other additives. The fuel was iron powder, manganese powder or carbon powder.  $\text{BaO}_2$  and  $\text{MnO}_2$  etc were also added as chlorine adsorbent and binder. Glass fiber and steel wool were also used to increase strength of the candles. One can expect this kind of candle will have high operation temperature. In 1972, US Patent No. 3702305 described the use of peroxide additive to catalyze the decomposition and significantly brought down the decomposition temperature. But adding highly hygroscopic  $\text{Na}_2\text{O}$  or  $\text{Na}_2\text{O}_2$  can cause a lot of inconvenience for fabrication, manufacture and storage. In 1978, US Patent 4073741 described  $\text{CoO}$  or  $\text{Co}_3\text{O}_4$  catalyzed  $\text{NaClO}_3$  oxygen candle. The candle contained a small amount of  $\text{NaClO}_4$ , and used little or no fuel at all. The Burning temperature of the candle was lowered to below the melting temperature of  $\text{NaClO}_3$ . The most preferred composition of the oxygen generator is (percentage weight): 96  $\text{NaClO}_3$ , 0-0.5  $\text{NaClO}_4$ , 1.5  $\text{CoO}$ , 0-4  $\text{BaO}_2$ , and 0-1 ceramic fiber. It was described that adding certain porosity aluminosilicate ceramic fiber can modify catalytic decomposition. The  $\text{BaO}_2$  added can both release oxygen and adsorb chlorine. In addition a small amount of fiber glass was also used to increase the strength of the candle. Winfried, K.R. et al pointed out that transition metal oxides, especially some p-type oxides have active catalytic effect for sodium chlorate decomposition. Therefore, it is possible to reduce fuel loading and make  $\text{NaClO}_3$  evolve oxygen at lower temperature (J. Phys. Chem., 74, 3317(1970)). But it is hard to get high purity chemicals such as  $\text{MnO}_2$  and  $\text{Fe}_2\text{O}_3$ . Increase loading of these oxides can also cause the oxygen generated to contain relatively high concentration of chlorine. When used as binder or excipient, steel wool and fiber glass segregates and results in problems for fabrication and pressing of the candles. Loading of steel wool often results in contamination of  $\text{CO}$  and  $\text{CO}_2$ . Loading of  $\text{BaO}_2$  as  $\text{Cl}_2$  suppressant can cause slow ignition. Due to the problems in design and formulation in the prior techniques, there is a laggard in oxygen evolution, that is, there is little or no oxygen is released in several seconds after initiation. This invention is to overcome the problems in the prior techniques. A quick initiation, no laggard in oxygen release. high rate and smooth oxygen evolution candle is invented. The candle has a total oxygen production of 6 liters and a duration of approximately 1 minute. The surface temperature of the generator is lower than  $250^\circ\text{C}$ . A

catalyzed decomposition type chemical oxygen candle formulation is invented. It contains little or no fuel and thus with low heat release, which results in lower candle temperature.

Figure 1 is the fabrication diagram of the said oxygen candle. It is comprised of ignition pellet 3, flash layer 4, and candle body 5. At the bottom of the candle body there is a fiber glass pad 8. Filter chamber 9 contains granular  $\text{Na}_2\text{O}_2$  and hopcalite. At the bottom of the filter chamber is lock washer 10. On the top of generator house can 6 is percussion primer 1 and primer striker 13. At the bottom of the can are washer 11 and gas outlet 12. On the top of candle body is fiber glass pad 2 which is used as thermal insulator and to prevent splash. Supporter 7 is used to secure the candle inside of the can. There is a gap between the candle core and the can for oxygen to flow out. When the primer is stricken, the ignition pellet is ignited. The ignition pellet ignites the flash layer and the flash layer ignites the candle body. The burning front proceeds along the candle body until completion. The oxygen generated flows out in the reversed direction of the burning front movement, which can help to warm up the unburned part of the candle and lower the outlet oxygen temperature. The three step ignition design warrants fast initiation and smooth oxygen evolution.

The key points of this invention are candle design and chemical formulation. The major component of the candle is  $\text{NaClO}_3$ . We found that  $\text{Co}_2\text{O}_3$  or mixture of  $\text{Co}_2\text{O}_3$  and  $\text{MnO}_2$  are good catalysts for  $\text{NaClO}_3$  decomposition. A suitable amount of the catalyst can bring down the decomposition temperature of  $\text{NaClO}_3$  below  $260^\circ\text{C}$  and thus greatly reduce the ratio of fuel loading (even reduce to 0% fuel). The oxygen generated also has high purity. The clay type minerals, especially Kaolin and zeolite etc., as excipients can also bring down the decomposition temperature of  $\text{NaClO}_3$ . But their main function is as a binder. The excipients can increase integrity of the candle core, keep the core from melting and flowing away, and thus result in smooth burning. Loading of these inert materials can also make the candle burn at lower rates. Therefore, the rate of oxygen evolution can be modified by using different ratio of the catalysts, additives and/or excipients.

$\text{Li}_2\text{O}_2$  is used in place of the popularly candle component  $\text{BaO}_2$  as a chlorine suppressant and oxygen source in the candle invented. We found that  $\text{NaClO}_3$  candle containing  $\text{Li}_2\text{O}_2$  is much better than candle containing  $\text{BaO}_2$  in ignition and burning and thus improve the performance of the candle. The flash layer is rich in fuel and burns fast, which provides high initial oxygen evolution rate and supply sufficient heat to warm up and ignites the candle body. In order to keep the candle core from contacting with the house

can and making the outside surface too hot, a shrinking agent  $B_2O_3$  can be added to the flashing layer, which can make the burn residue shrink. The candle body can contain little or no fuel. Addition of a small amount of electrolytic  $MnO_2$  can also provide high purity for the oxygen evolved.

The said flash layer in this invention can have composition as follow (weight %)

$NaClO_3$	70 - 90
Mg	1.0 - 10
$B_2O_3$	0 - 6
$Co_2O_3$	0 - 7
$Li_2O_2$	1 - 7
Kaolin	1 - 10

The candle body in this invention has composition as follow (weight %)

$NaClO_3$	81 - 96
Mg	0 - 5.0
$Co_2O_3$	2.0 - 7.0
Mn	0 - 5.0
$Li_2O_2$	1.0 - 6.5
Kaolin	1.0 - 8.0

The oxygen candle in this invention is a  $NaClO_3$  catalyzed decomposition type. Little or no fuel is needed and the candle can self-sustain burning and generate high purity oxygen. The heat release is low and the maximum temperature of the candle house can is lower than  $250^\circ C$ . The amount of oxygen can be generated is: first 30 seconds after initiation > 2 liters; first 50 seconds > 4 liters, and th total oxygen generation > 6 liters.

The component chemicals for the flash layer and candle body are weighed and mixed to uniformity separately. The mixtures are then poured into a mold and pressed into a candle core. It is advantageous to press the flashing layer on top of the candle body. A hollow is made on top of the flash layer to hold the ignition pellet.

#### EXAMPLE I

Flash layer composition (weight %, same hereafter): 79  $NaClO_3$ , 5 Mg, 5  $Co_2O_3$ , 5  $Li_2O_2$  and 6 kaolin;

Candle body composition: 84  $NaClO_3$ , 2 Mg, 5  $Co_2O_3$ , 3.5  $Li_2O_2$  and 4.5 kaolin.

The chemicals of the flashing layer and candle body were dried and mixed separately and then poured into a mold and pressed into a cylindrical candle core with a length of 18 mm and a diameter of 30 mm. The pressure is  $1.2T/cm^2$ . The candle was then fabricated. A ceramic disc or a fiber glass pad was put on the top of the ignition pellet, which

was used as heat insulator and to prevent splashing. The candle core was secured inside of the house can. The filtering chamber was filled with granular  $\text{Na}_2\text{O}_2$ . A fiber glass pad and a spring were used on the top of the chamber. The end cap was then welded. After the burning, the oxygen yield of the candle was calculated as 39% based on weight change.

#### EXAMPLE II

Flash layer: 83  $\text{NaClO}_3$ , 1 Mg, 7  $\text{Co}_2\text{O}_3$ , 4  $\text{Li}_2\text{O}_2$ , and 5 kaolin; candle body: 90  $\text{NaClO}_3$ , 1.5 Mg, 4.5  $\text{Co}_2\text{O}_3$ , 1.5  $\text{Li}_2\text{O}_2$ , 2.5 kaolin. The chemicals were dried and mixed and then pressed into candle core. The pressure was  $1.5\text{T/cm}^2$ . The core had a bulk density of  $2.0\text{g/cm}^3$ . The candle was fabricated in the same procedure as described in example I. The oxygen yield was calculated as 41% based on weight change.

#### EXAMPLE III

Flash layer: 76  $\text{NaClO}_3$ , 6 Mg, 5  $\text{Co}_2\text{O}_3$ , 3  $\text{B}_2\text{O}_3$ , 4  $\text{Li}_2\text{O}_2$  and 6 kaolin; candle body: 91  $\text{NaClO}_3$ , 1 Mg, 5  $\text{Co}_2\text{O}_3$ , 1  $\text{Li}_2\text{O}_2$ , and 2 kaolin. The pressing and fabrication procedure were the same as described in example II. The oxygen yield was calculated as 41% based on weight change.

#### EXAMPLE IV

Flash layer: same as in example I; candle body: 91.5  $\text{NaClO}_3$ , 0.5 Mg, 5  $\text{Co}_2\text{O}_3$ , 1  $\text{Li}_2\text{O}_2$ , and 2 kaolin. The candle core was pressed and fabricated as described in example II. The oxygen yield was calculated as 41%.

#### EXAMPLE V

Flash layer: same as in example III; candle body: 92  $\text{NaClO}_3$ , 0 Mg, 6  $\text{Co}_2\text{O}_3$ , 1  $\text{Li}_2\text{O}_2$ , and 1 kaolin. The candle core was pressed and fabricated as described in example II. Oxygen yield was calculated as 41%.

#### EXAMPLE VI

Flash layer: 77  $\text{NaClO}_3$ , 8 Mg, 4  $\text{B}_2\text{O}_3$ , 5  $\text{Li}_2\text{O}_2$ , and 6 kaolin; candle body: 89  $\text{NaClO}_3$ , 1 Mg, 3  $\text{Co}_2\text{O}_3$ , 2  $\text{MnO}_2$ , 2  $\text{Li}_2\text{O}_2$ , and 3 kaolin. The candle core was pressed and fabricated as described in example I. The ratio of oxygen weight/candle weight was calculated as 41% based on weight difference before and after burning.

#### EXAMPLE VII

Flash layer was the same as in example VI; candle body: 86  $\text{NaClO}_3$ , 1 Mg, 3  $\text{Co}_2\text{O}_3$ , 2  $\text{MnO}_2$ , 3  $\text{Li}_2\text{O}_2$ , and 5 kaolin. The candle core was pressed and fabricated as described in example I. The ratio of oxygen weight to candle weight was calculated as >40% based on weight difference before and after the burning.

(19) 中华人民共和国专利局

公开号 CN 1035248A



# (12) 发明专利申请公开说明书

[21] 申请号 89100611.7

[51] Int. Cl.  
A62B 7/08

[43] 公开日 1989年9月6日

[22] 申请日 89.1.28

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Complies with Copyright Law  
CAS Document Delivery Service  
1-614-447-3670

说明书页数: 6 附图页数: 1

[54] 发明名称 氯酸钾氧烛

[57] 摘要

一种可用于在缺氧环境中自救使用的化学氧源——催化分解氯酸钾氧烛，特别适合于作化学氧自救器的启动装置。氧烛主成份为  $\text{KClO}_3$ ；另有适当的催化添加剂和成型剂等。氧烛由撞击火焰点燃后即能持续燃烧并放出高纯氧气。放氧速度快而总放热量很小。

030590

(BJ)第1456号

## 权 利 要 求 书

1. 一种以氯酸钠为主要成份的氧烛，特别适合于作化学氧自救器的启动装置，本发明的特征是氧烛主体由引火片、发热体和烛体三部分组成。

2. 根据权利要求1所述的氧烛，其特征为氧烛烛体由（重量百分数，下同） $\text{NaClO}_3$  81~96， $\text{Mg}$  0~5.0， $\text{Co}_2\text{O}_3$  2.0~7.0， $\text{MnO}_2$  0~5.0， $\text{Li}_2\text{O}_2$  1.0~6.5，高岭土1.0~8.0组成。

3. 根据权利要求1所述的氧烛，其特征为氧烛发热体由 $\text{NaClO}_3$  70~90， $\text{Mg}$  1~10， $\text{Co}_2\text{O}_3$  0~7， $\text{B}_2\text{O}_3$  0~6， $\text{Li}_2\text{O}_2$  1~7，高岭土1~10组成。

4. 根据权利要求1所述的氧烛，其特征为用撞击机壳上火帽点燃引火片，引火片再依次点燃发热体、烛体，并使之持续稳定燃烧释放供人呼吸用高纯氧气。

5. 根据权利要求1所述的氧烛，其特征是氧烛属氯酸钠催化热分解型。用很少或不用燃料，一经点燃即能自行持续燃烧分解并产生供人呼吸用高纯氧气。

6. 根据权利要求1所述的氧烛，其特征是通过改变催化添加剂或成型剂含量，可以改变氧烛的放氧速度。



氯 酸 钠 氧 烛

本发明属于化学氧发生器，而特别适合于作化学氧自教器启动装置。

化学氧发生器——氯酸钠氧烛，已早为人所知。国外从六、七十年代始已有多项专利申请。这种氧烛除主成份  $\text{NaClO}_3$  外，尚含燃料和其它添加成份。燃料多为  $\text{Fe}$ 、 $\text{Mn}$ 、 $\text{C}$  粉等；另外还加入如  $\text{BaO}_2$ 、 $\text{MnO}_2$  等除氯剂及粘结剂。为了保证氧烛强度，还常加入玻璃纤维或钢毛等。可想而知，这种氧烛燃烧温度很高。1972 年美国 3702305 号专利曾提出催化分解添加过氧化物，使氧烛燃烧温度大为降低。但由于加入了吸湿性强的  $\text{Na}_2\text{O}$  和（或） $\text{Na}_2\text{O}_2$ ，却给氧烛加工、装配和贮存带来了很多不便。1978 年美国第 4073741 号专利提出用  $\text{CoO}$  或  $\text{Co}_3\text{O}_4$  催化分解  $\text{NaClO}_3$  的氧烛。该氧烛一般常含有少量  $\text{NaClO}_4$ ，只用很少或不用燃料。氧烛燃烧温度降到  $\text{NaClO}_3$  熔点以下。该氧烛最佳组成为（重量百分数）：96  $\text{NaClO}_3$ ，0~0.5  $\text{NaClO}_4$ ，1.5  $\text{CoO}$ ，0~4  $\text{BaO}_2$ ，0~1 陶瓷纤维。选择有一定孔隙度的硅铝酸盐陶瓷纤维作添加剂，据称可起控制催化分解的作用。所加  $\text{BaO}_2$  兼有放  $\text{O}_2$  和吸收  $\text{Cl}_2$  的作用。另外还加少量玻璃纤维作增强剂。Winfried, K.R. 等人曾研究指出，过渡金属氧化物，特别是具 P-型半导体性质的氧化物均对氯酸盐分解有很好的催化作用。因而可望降低氧烛燃料比，并在较低温度下使  $\text{NaClO}_3$  分解放  $\text{O}_2$

(J. Phys. Chem., 74, 3317 (1970)). 但由于  $\text{MnO}_2$ ,  $\text{Fe}_2\text{O}_3$  等很难得到好的纯制品, 使用量稍大时, 常引起放氧中  $\text{Cl}_2$  含量偏高。作为成型剂或增强剂, 钢毛和玻璃纤维之类容易成团, 引入此类物质常给加工成型造成困难。而钢毛又常引起有  $\text{CO}$  和  $\text{CO}_2$  的产生。而且加入  $\text{BaO}_2$  除  $\text{Cl}_2$  剂可致使氧烛点火迟钝。况已有技术由于其设计、成份和配方的缺点, 在使用中有放氧滞后现象, 即氧烛在启动后的前几秒钟内不释放或少释放氧气。本发明便是克服上述已有技术的缺点, 研制了一种启动迅速, 无滞后, 放氧速度快而平稳的氧烛。在总放氧量为 6 升, 燃时  $\sim 1$  分钟时, 机制外壳表面温度低于  $250^\circ\text{C}$ 。它特别适合于作化学氧自救器启动装置使用。同时也提供一种催化分解  $\text{NaClO}_3$  型氧烛化学组分。它仅含少量或不含燃料, 释放很少热量, 以保障较低的氧烛总体温升。

6 liter  $\text{O}_2$   
total in  
a 1 min.  
Suitable  
for PBE's

附图 1 为氧烛主体工装示意图。氧烛主体由引火片 3、发热体 4 和烛体 5 组成。主体底部有玻璃纤维垫 8。过滤罐 9 内装颗粒  $\text{Na}_2\text{O}_2$ , 或霍去来特 (Hopcalite), 最后是压紧簧片 10。机制外壳 6 的上部有火帽 1 和火帽撞击机构 13。下部有密封膜 11 和出气口 12。为隔热和防止上喷火, 在主体最上部还垫有玻璃纤维垫 2。7 是固定夹, 用以夹紧氧烛主体并固定于机壳内, 药柱与壳体间有一适当空隙以便气体流出。由撞击机壳上火帽点燃引火片后, 引火片接着点燃发热体并依次向下持续燃烧到完全。燃烧时所放气体逆向流出, 既加热了氧烛主

体，又降低了出口气体温度。氧烛主体设计分段，保证了氧烛启动快，无滞后，燃烧放氧平稳。

本发明的要点是指氧烛的主体设计和化学组成。氧烛主成份为  $\text{NaClO}_3$ ，我们发现  $\text{Co}_2\text{O}_3$  或  $\text{Co}_2\text{O}_3$  与  $\text{MnO}_2$  的混合物是  $\text{NaClO}_3$  分解的很好的催化剂。添加适当的量可使  $\text{NaClO}_3$  分解温度降低到低于  $260^\circ\text{C}$ 。因而可大大降低氧烛的燃料比（甚至到零）。且能保证放  $\text{O}_2$  的高纯度。本发明中的成型剂粘土类矿物，特别是高岭土，沸石等的加入也会降低  $\text{NaClO}_3$  的热分解温度，但主要作用是使氧烛粘结成型。它保证了加工药柱强度，又使燃烧物不熔融流淌，保证了氧烛稳定燃烧。这类惰性物质加入也降低了氧烛燃烧速度，因而通过改变催化添加剂或（和）成型剂的含量可以控制氧烛放氧速度。

$\text{Li}_2\text{O}_2$  作为除  $\text{Cl}_2$  和放  $\text{O}_2$  物质被引入本发明的氧烛中，而取代普遍使用的  $\text{BaO}_2$ 。我们发现含  $\text{Li}_2\text{O}_2$  的氯酸钠氧烛，其点火和燃烧灵敏度大大优于含  $\text{BaO}_2$  的氧烛，因而提高了氧烛的使用和放氧性能。发热体有足够的燃料，燃烧速度快，保证了初期放氧速度；并提供足够热量预热和点燃烛体部分。为了使发热体燃烧时不与外壳接触造成外壳温升过高，在发热体中可加入收缩剂  $\text{B}_2\text{O}_3$ ，目的是使燃后残物体积收缩。烛体可以少含或不合燃料。加少量电解  $\text{MnO}_2$  亦能保证放出  $\text{O}_2$  的高纯度。

本发明氧烛发热体组成可以是（重量%）：

	$\text{NaClO}_3$	70~90
	Mg	1.0~10
	$\text{B}_2\text{O}_3$	0~6
	$\text{Co}_2\text{O}_3$	0~7
	$\text{Li}_2\text{O}_2$	1~7
Gaolin	高岭土	1~10

本发明氧烛体组成范围为(重量%):

	$\text{NaClO}_3$	81~96
	Mg	0~5.0
	$\text{Co}_2\text{O}_3$	2.0~7.0
	$\text{MnO}_2$	0~5.0
	$\text{Li}_2\text{O}_2$	1.0~6.5
Gaolin	高岭土	1.0~8.0

本发明的氧烛属  $\text{NaClO}_3$  催化热分解型。用很少或不用燃料即能保证自己持续燃烧分解产生高纯氧气，而释放很少热量。它保证了氧烛壳体温升小于  $250^\circ\text{C}$ 。放氧量为：启动后前30秒  $> 2$  升；前50秒  $> 4$  升；总放  $\text{O}_2$  量  $> 6$  升。

实现本发明时，可将发热体、烛体分别配料、混匀后装入模具，用压力机压制成型。最好再把发热体与烛体压在一起。发热体上部存一凹坑，便于放置引火片。

发明人曾做了大量实施工作。下面列举7例。

例1: example 1

氧烛发热体组成(重量%, 下同):  $79\text{NaClO}_3$ ,  $5\text{Mg}$ ,  
 $5\text{Co}_2\text{O}_3$ ,  $5\text{Li}_2\text{O}_2$ ,  $6$  高岭土; kaolin

氧烛烛体组成:  $84\text{NaClO}_3$ ,  $2\text{Mg}$ ,  $5\text{Co}_2\text{O}_3$ ,  $3.5\text{Li}_2\text{O}_2$ ,  
 $4.5$  高岭土.

将发热体、烛体的各组分分别干燥、混匀, 放入模具压制成  $\varnothing$  30mm, 高18mm的圆柱体。压力  $1.2\text{T/cm}^2$ 。脱模后进行总体组装。引火片上方有一带孔陶片或玻璃纤维棉垫, 用以隔热和防止后喷火。药柱夹紧固定于壳体内。过滤罐内放干燥的  $\text{Na}_2\text{O}_2$  颗粒。过滤罐后部加玻璃棉垫和弹簧片, 压紧后焊封壳底。氧烛燃完后, 根据放氧量  
和氧烛燃烧前后重量变化, 计算有效氧/重量比为 39 %.

例2: example 2

发热体:  $83\text{NaClO}_3$ ,  $1\text{Mg}$ ,  $7\text{Co}_2\text{O}_3$ ,  $4\text{Li}_2\text{O}_4$ ,  $5$  高岭土。烛体:  $90\text{NaClO}_3$ ,  $1.5\text{Mg}$ ,  $4.5\text{Co}_2\text{O}_3$ ,  $1.5\text{Li}_2\text{O}_2$ ,  $2.5$  高岭土。将药品干燥、混匀, 放入模具压制成型, 压力  $1.5\text{T/cm}^2$ 。成品药柱比重  $2.0\text{g/cm}^3$ , 组装同例1。根据放氧量及燃烧前后重量变化, 计算有效氧/重量比为 41 %.

例3:

发热体组成:  $76\text{NaClO}_3$ ,  $6\text{Mg}$ ,  $5\text{Co}_2\text{O}_3$ ,  $3\text{B}_2\text{O}_3$ ,  $4\text{Li}_2\text{O}_2$ ,

6 高岭土；烛体组成： $91\text{NaClO}_3$ ,  $1\text{Mg}$ ,  $5\text{Co}_2\text{O}_3$ ,  $1\text{Li}_2\text{O}_2$ , 2 高岭土。成型、组装同例 2。根据放氧量及重量改变，计算有效氧/重量比为 41 %。

例 4：

发热体组成同例 1。烛体组成为： $91.5\text{NaClO}_3$ ,  $0.5\text{Mg}$ ,  $5\text{Co}_2\text{O}_3$ ,  $1\text{Li}_2\text{O}_2$ , 2 高岭土。成型、组装同例 2。计算有效氧/重量比为 41 %。

例 5：

发热体同例 3。烛体组成： $92\text{NaClO}_3$ ,  $0\text{Mg}$ ,  $6\text{Co}_2\text{O}_3$ ,  $1\text{Li}_2\text{O}_2$ , 1 高岭土。成型、组装同例 2。计算有效氧/重量比为 41 %。

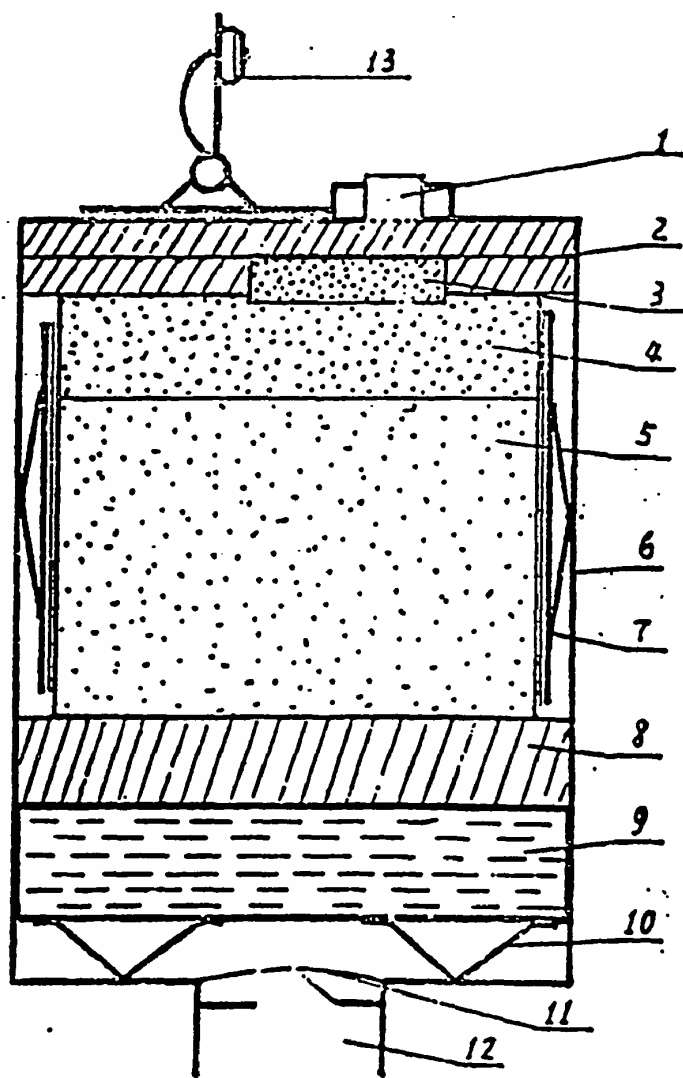
例 6：

发热体组成为： $77\text{NaClO}_3$ ,  $8\text{Mg}$ ,  $4\text{B}_2\text{O}_3$ ,  $5\text{Li}_2\text{O}_2$ , 6 高岭土；烛体组成为： $89\text{NaClO}_3$ ,  $1\text{Mg}$ ,  $3\text{Co}_2\text{O}_3$ ,  $2\text{MnO}_2$ ,  $2\text{Li}_2\text{O}_2$ , 3 高岭土。成型、组装同例 1。根据放氧量及燃烧前后重量变化，计算有效氧/重量比为 41 %。

例 7：

发热体同例 6。烛体组成为： $86\text{NaClO}_3$ ,  $1\text{Mg}$ ,  $3\text{Co}_2\text{O}_3$ ,  $2\text{MnO}_2$ ,  $3\text{Li}_2\text{O}_3$ , 5 高岭土。成型、组装同例 1。根据放氧量和燃烧前后重量变化，计算有效氧/重量比  $> 40\%$ 。

# 说明书附图



附图 1.